NASA Mission Directorate Panel

Moderated by Jenn Gustetic, NASA SBIR/STTR Program Executive

Cheryl Quinn, NASA Aeronautics Research Mission Directorate

Lindsay Aitchison, NASA Human Exploration and Operations Mission Directorate

Michael Seablom, NASA Science Mission Directorate

Jason Derleth, NASA Space Technology Mission Directorate

From SBIR to X-Plane: ARMD SBIR Success Story

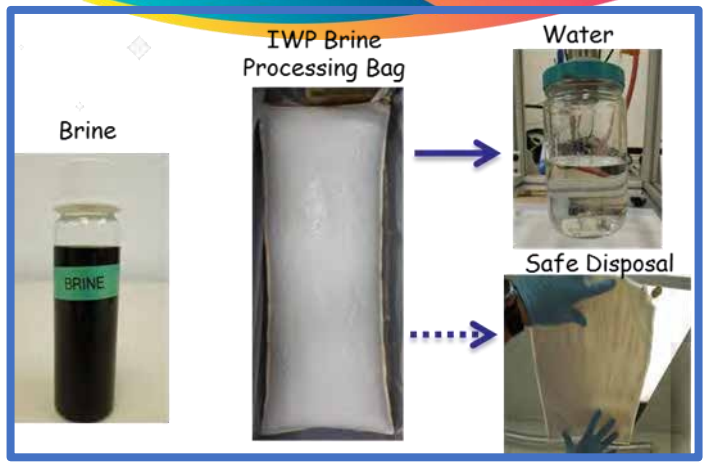
SCEPTOR (Scalable Convergent Electric Propulsion Technology Operations Research)

- With 14 electric motors turning propellers integrated into a uniquely-designed wing, NASA will test new propulsion technology using an experimental airplane now designated the X-57.
- After a successful SBIR in 2009 with NASA Glenn looking at a hybrid electric aircraft concept utilizing superconducting generators, Empirical Systems Aerospace, Inc. began to focus on non-superconducting technologies. A few years later, SCEPTOR took form and it is allowing NASA to explore next generation electric aircraft designs.

NASA's X-57 "Maxwell" Aircraft

HEO SBIR Success Story: Ionomer-membrane Water Processor

- NASA Problem: For regenerative wastewater recycling systems, brine wastewater production results in a considerable loss of water on a yearly basis. It is highly toxic. Consumable containers are used to dispose of the brine, which adds significant consumable mass.
- SBIR Awarded to Paragon Space Development Corp. for Ionomer-membrane Water Processor (IWP)
  - SBIR Phase 1 Awarded: 2/18/2011
  - SBIR Phase 2 Awarded: 5/18/2012
  - SBIR Phase 3 Awarded: 4/13/2015
- Technology was competitively selected for infusion in to Brine Processor Assembly (BPA) Project under Advanced Exploration Systems
  - Using SBIR technology, BPA will improve water recovery process on the ISS by increasing water loop closure to >98%, meeting the technology maturation objective for human missions to Mars.
  - The ISS demo will validate and fully characterize Brine Processor system performance in a relevant environment for future exploration missions.
  - This test will define the state of the art for recovery of potable water from wastewater.
- Objective: Recover up to 80% of available water from 22.5 liters of brine within a 26 day cycle. BPA consumables (bladders) mass shall not exceed 0.25 lb hardware for every lb of water recovered from brine.
- **Status:** BPA will be delivered for flight in Feb 2020.



IWP functional description

ISS Brine Processor Assembly – Brine bladder installed

SMD SBIR Success Stories: Curiosity Rover

Grammatech: Software for eliminating defects in mission-critical and embedded software applications

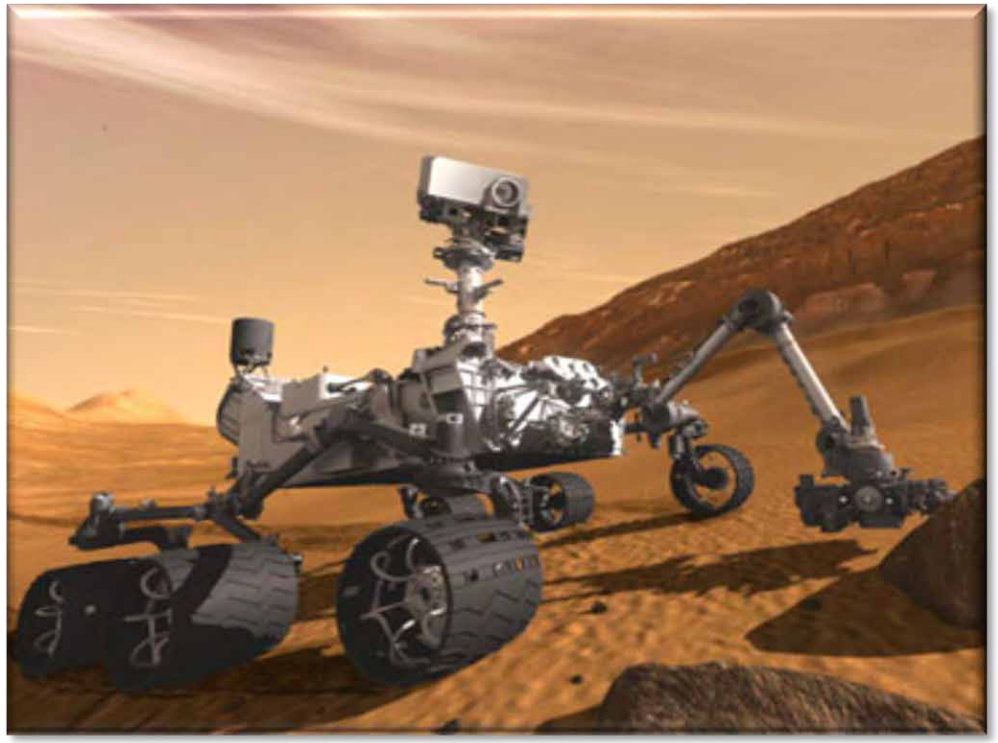
Starsys Research: Gearboxes for the articulated robotic arm and the descent braking mechanism

Creare: A space-qualified vacuum pump for the Sample Analysis at Mars (SAM) instrument package\

Yardney Technical Products: Custom lithium ion batteries

Honeybee Robotics: Dust removal tool for rock surfaces and for SAM

inXitu: Contributed to automated sample handling system are part of the Chemistry and Mineralogy experiment (CheMin)



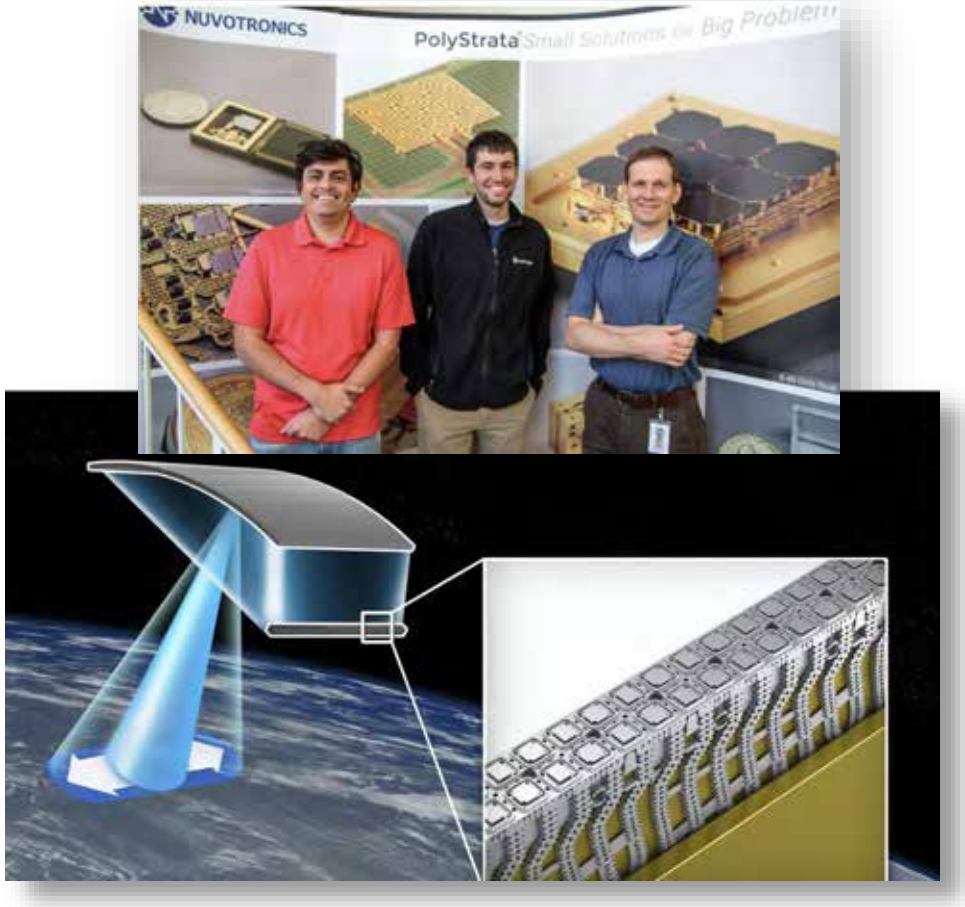
SMD SBIR Success Stories: PolyStrata®

NASA's Jet Propulsion Laboratory (JPL) was developing a small satellite radar that was capable of collecting cloud data at multiple simultaneous frequencies.

Nuvotronics, Inc. collaborated with JPL to develop an antenna that performs transmit/receive to collect data at multiple frequencies simultaneously, using a custom process known as PolyStrata®.

Their ability to produce small, agile science instruments greatly contributes to NASA's research capabilities.

During Phase III over $45 million was received from non-SBIR government and commercial customers.



STMD SBIR Success Story: HYDROS

PHASE III SUCCESS

$2.2 million in contracts from NASA and Millennium Space Systems to test the HYDROS system prototype.

SNAPSHOT

Tethers Unlimited created a CubeSat Thruster using a sustainable and renewable propellant created from water-electrolysis for NASA space research and commercial ventures.

CUBESAT THRUSTERS POWERED BY GREEN PROPELLANT

Tethers Unlimited, Bothell, Washington

Innovation

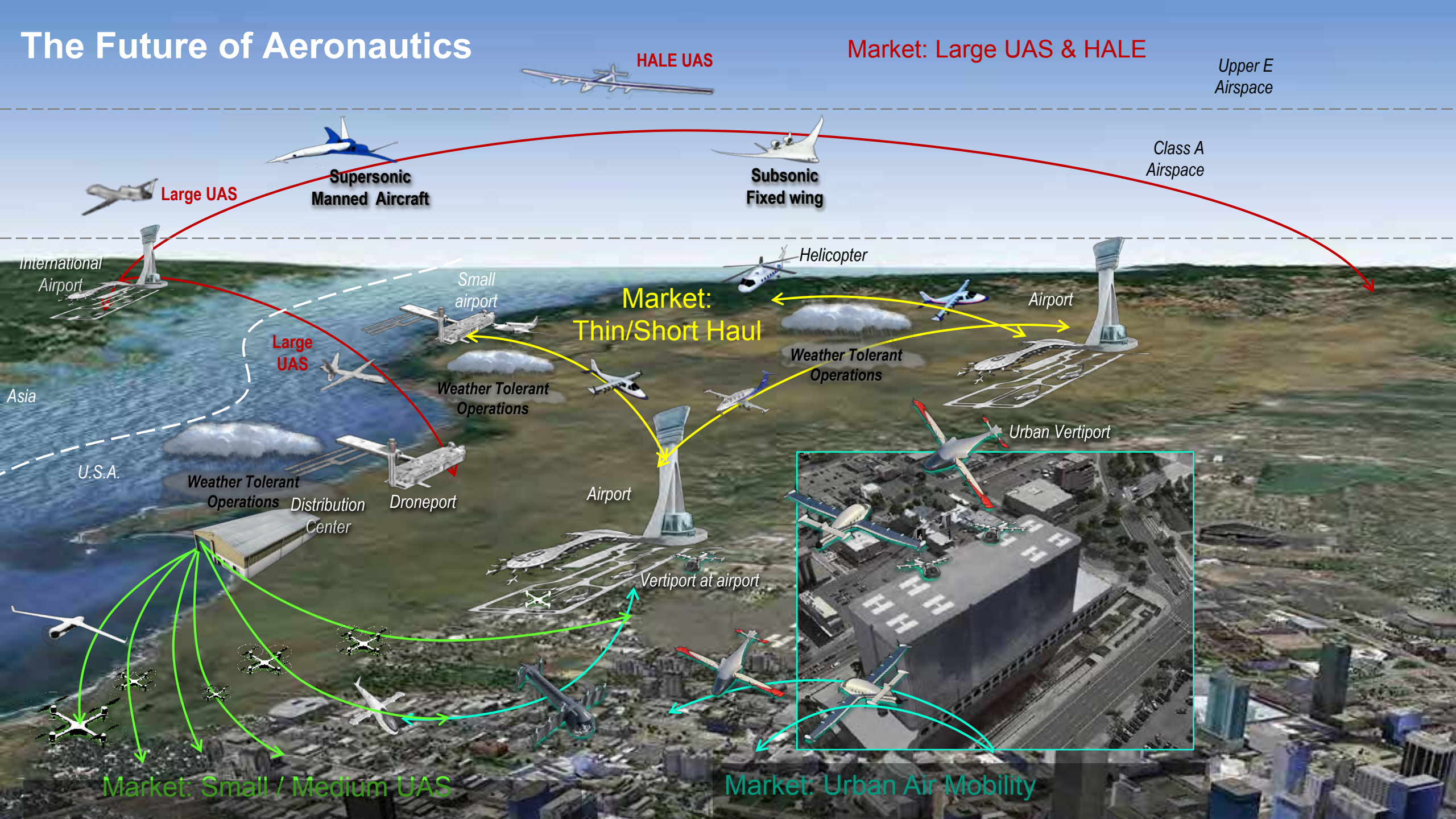
“Tethers Unlimited, Inc.’s (TUI) green propulsion system called HYDROS is used to power CubeSats (a type of miniaturized satellite.) CubeSats play a valuable role in NASA’s science, technology, and educational investigations. These mini-satellites provide a low-cost platform for NASA science missions, including planetary exploration.”

This safer and renewable propulsion system helps provide additional cost savings for government and commercial ventures by extending the CubeSat operational life and improving performance.

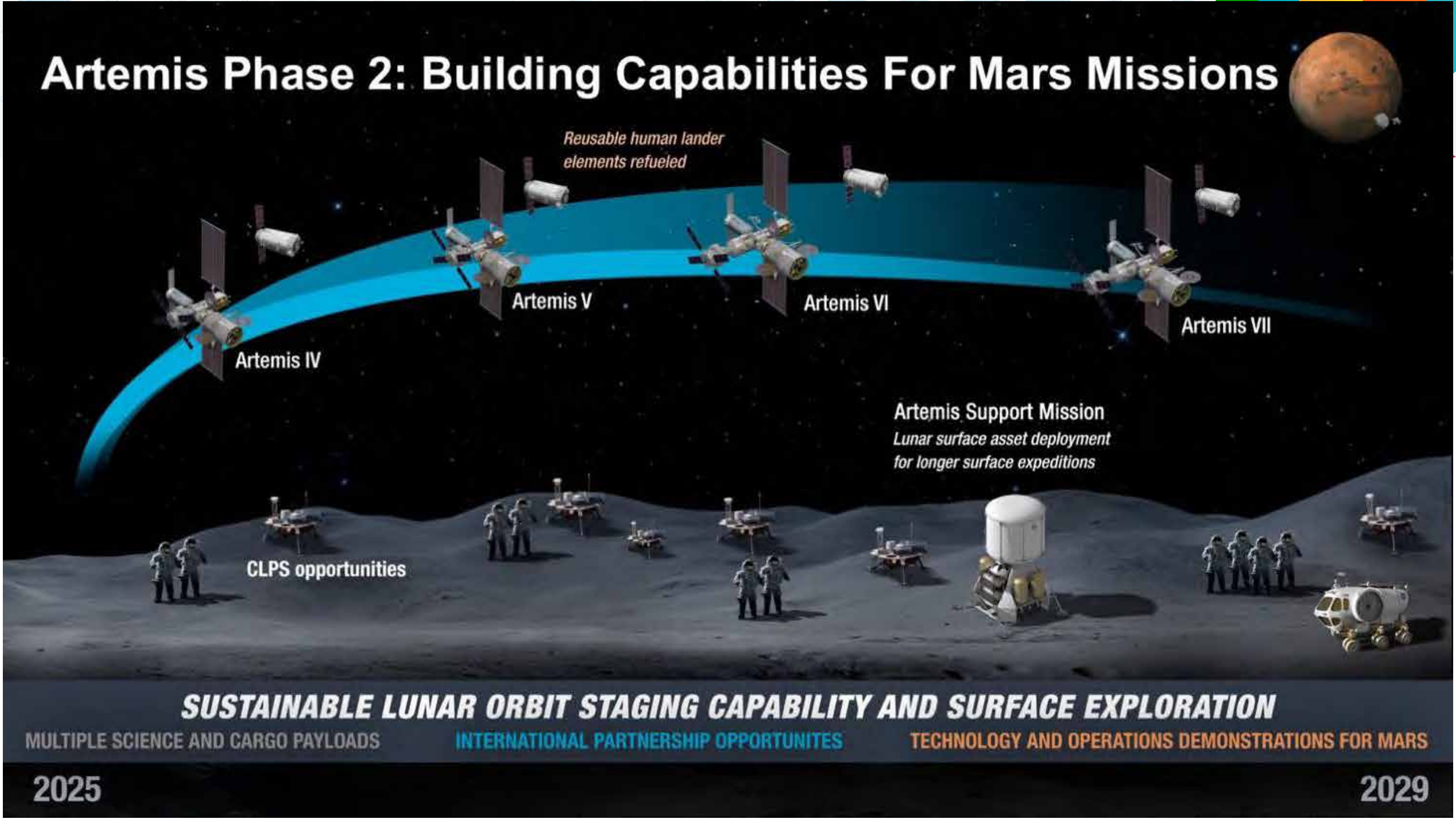
ARMD Overview

- NASA Aeronautics Strategic Implementation Plan (2017)
  - Advanced Air Vehicles Program
  - Airspace Operations and Safety Program
  - Integrated Aviation Systems Program
- ARMD Research is organized through roadmaps aligned with six Strategic Thrusts:

- New emphasis on emerging markets: More Electric Aircraft, Urban Air Mobility


The Future of Aeronautics
HALE UAS
Market: Large UAS & HALE
Upper E Airspace
Class A Airspace
Large UAS
Supersonic Manned Aircraft
Subsonic Fixed wing
International Airport
Helicopter
Small airport
Market: Thin/Short Haul
Airport
Large UAS
Weather Tolerant Operations
Weather Tolerant Operations
Asia
Urban Vertiport
U.S.A.
Weather Tolerant Operations
Distribution Center
Droneport
Airport
Vertiport at airport
Market: Small / Medium UAS
Market: Urban Air Mobility

Artemis Phase 2: Building Capabilities For Mars Missions

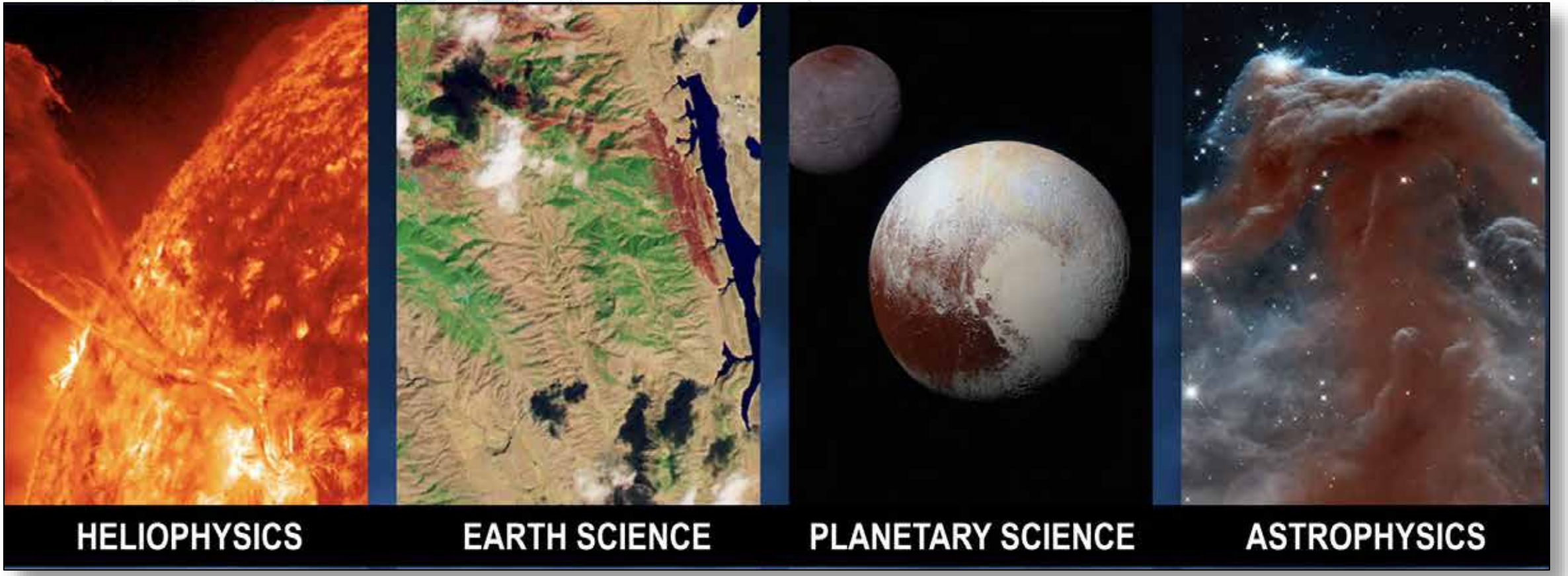


SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

MULTIPLE SCIENCE AND CARGO PAYLOADS | INTERNATIONAL PARTNERSHIP OPPORTUNITES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

2025 — 2029

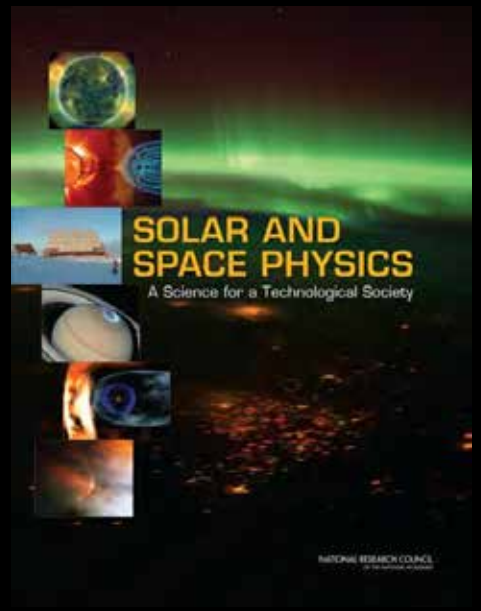
Overview of NASA Science



Overview of NASA Science

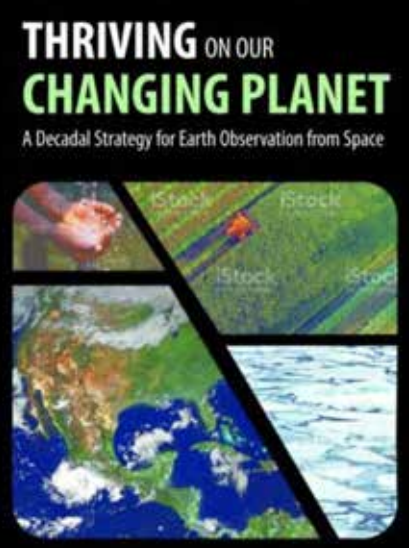
Strategically Planned Science Missions

Heliophysics



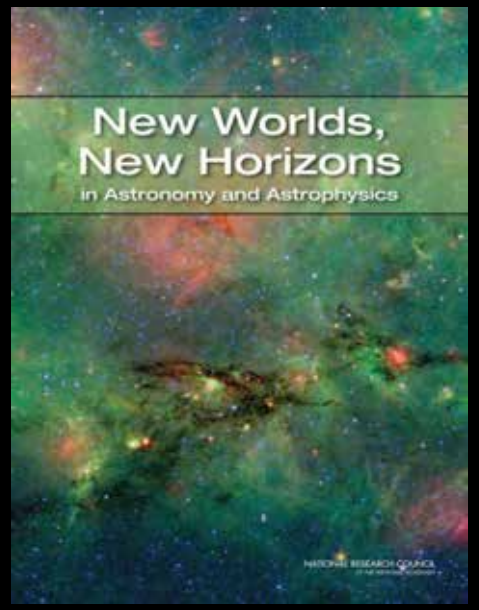
2013 – 2022

Earth Science



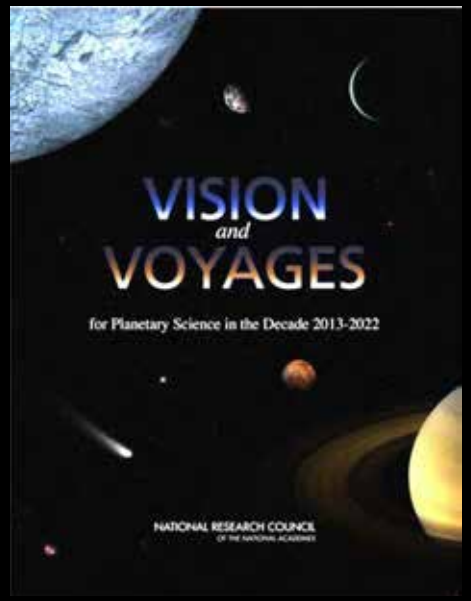
2017 – 2027

Planetary Science



2012 – 2021

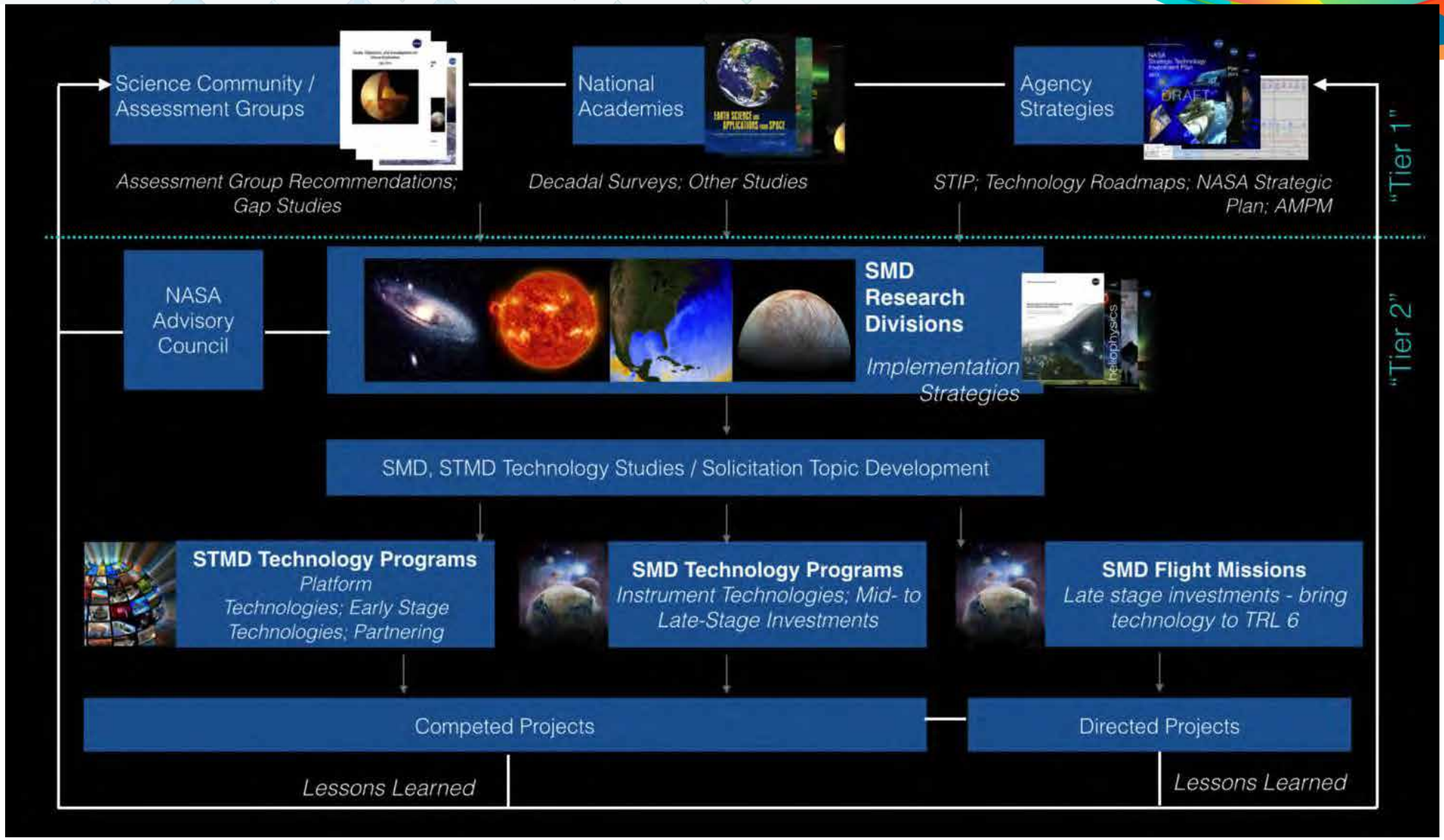
Astrophysics



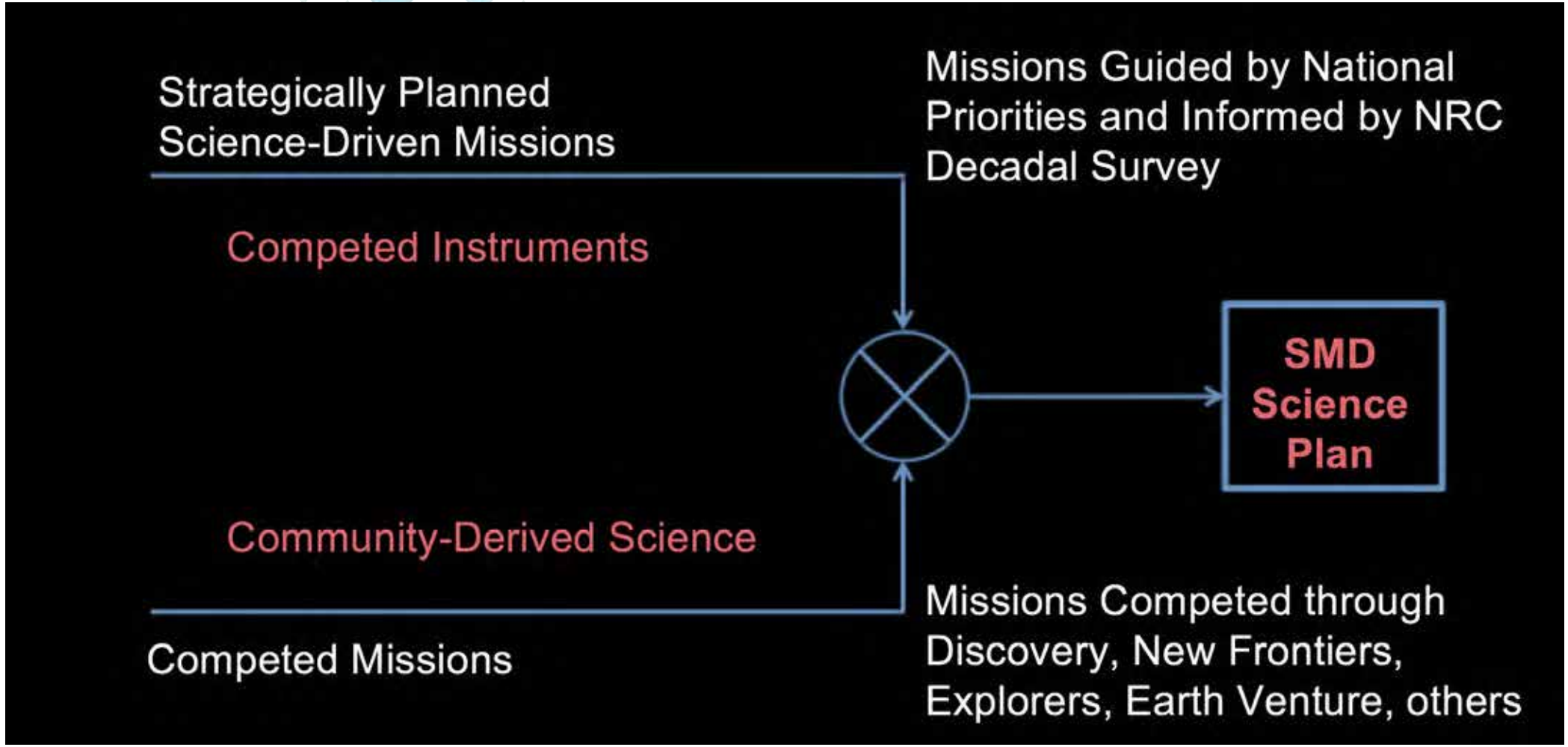
2012 – 2021

Decadal surveys organized by the National Academies on behalf of NASA establishing USA national priorities for scientific observations, as identified by the community, within a 10-year time frame

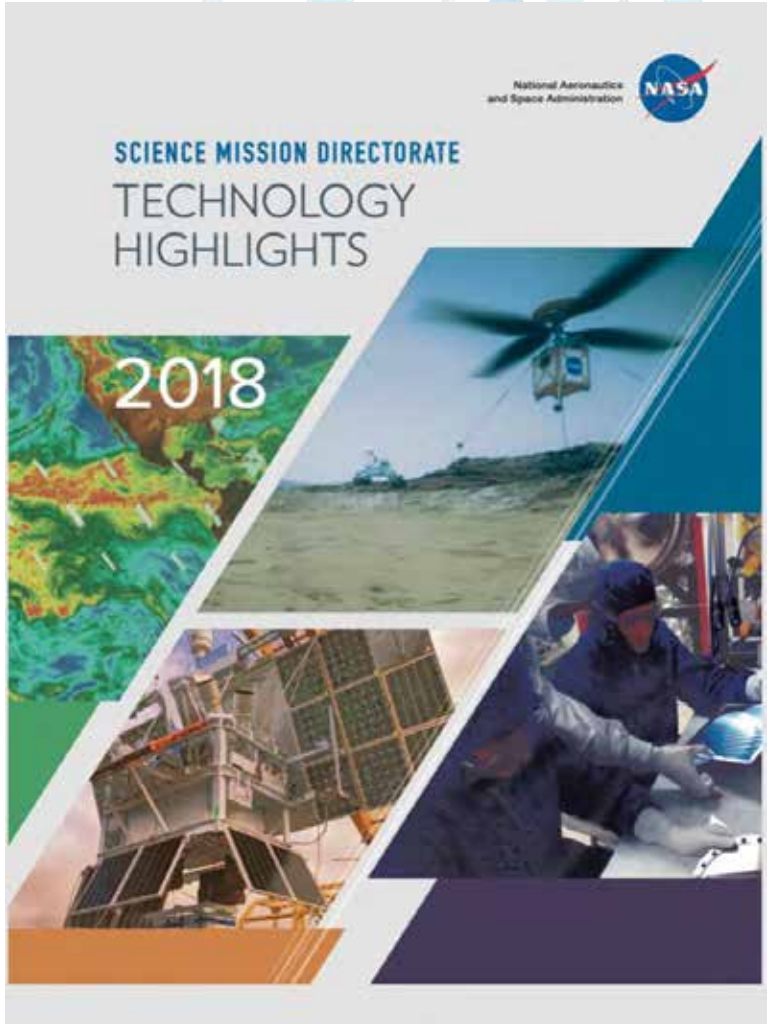
SMD Technology Ecosystem



SMD Planning Integrates Two Elements



SMD Technology: Our Philosophy



- Technology and continued technological progress is critical for SMD and its future missions
- Technology investments are pathways to flight as strategic elements of SMD programs
- SMD will actively develop flight opportunities for new technologies as part of AOs.
- Based on our experiences, performance metrics, and feedback, we will continuously adjust.

STMD Strategic Thrusts

Go: *Enable Safe and Efficient Transportation Into and Through Space*

- Provide safe, affordable, and routine access to space
- Provide cost-efficient, reliable propulsion for long duration missions
- Enable significantly faster, more efficient deep space missions

Land: *Increase Access to Planetary Surfaces*

- Safely and precisely deliver humans & payloads to planetary surfaces
- Increase access to high-value science sites across the solar system
- Provide efficient, highly-reliable sample return reentry capability

Live: *Enable Humans to Live and Explore in Space and on Planetary Surfaces*

- Provide in-space habitation and enable humans to live on other planets
- Provide efficient/scalable infrastructure to support exploration at scale
- Providing ability to safely explore and investigate high-value sites

Explore: *Expand Capabilities Through Robotic Exploration & Discovery*

- Expand access to new environments to enable high-value science
- Develop new means of observation, exploration, and characterization
- Enable substantial increase in the quantity and quality of science data

ARMD and Small Business

- ARMD external collaborations include other government agencies, academia, and industry (large, medium, and small businesses)
- External research is competition-based and includes Task Order Contracts, NASA Research Announcements (NRA), and SBIR/STTR
- SBIR/STTR is integral to overall competitive acquisition strategy
  - Tap into vast intellectual capital and innovative ideas in small business community
  - Serve as catalyst for small business growth and expansion
- Paths to commercialization
  - NASA – Infusion opportunities
  - Other Government – FAA, DoD, DHS
  - Industry – Aviation Manufacturers, Airlines, Service Providers
  - Direct Provider – Opportunities for Direct Commercialization in UAS/UAM ecosystem

HEOMD Acquisition Mechanisms

- Grant opportunities and information in NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES)
  - http://nspires.nasaprs.com/external/
- SBIR/STTR solicitations
- NextSTEP Awards
  - Human Landing System
  - Habitation Modules
  - Commercial Development Free Flyer
  - Stimulating Demand in LEO
  - Commercial Destinations in LEO
- ISS National Lab
  - www.spacestationresearch.com/research-on-station/opportunities/
- Collaborations with Research Institutes
  - SSERVI
  - RETHI
  - Smart Hab
- Contracts for Vehicle Systems

How HEO Infuses SBIR Technologies

- Tech Monitors are the key champions for transitioning SBIR Phase I activities
  - In many cases, have decision authority within NASA development activities that benefit from the technology
  - Identify customers for cost-sharing in Phase III
  - Provide increased context and requirements for technology infusion into systems
- SBIR technologies can be rolled into larger system development activities as part of an Advanced Exploration Systems project
- ISS utilization topics can lead to permanent capabilities on ISS

Funding Opportunities in SMD

PLANETARY SCIENCE DIVISION	
Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO)	Funds the development of low-TRL technologies (TRL 1-3) leading directly to the development of new Planetary Science observing instruments, sensors and in situ systems.
Maturation of Instruments for Solar System Exploration (MatISSE)	Matures innovative instruments, sensors, and in situ system technologies (TRL 3-6) to the point where they can be successfully infused into new Planetary Science missions.
Concepts for Ocean Worlds Life Detection Technology (COLDTech)	Supports the development of spacecraft-based instruments and technology for surface and subsurface exploration of ocean worlds such as Europa, Enceladus, and Titan.
Hot Operating Temperature Technology Program (HOTTech)	Supports the development of technologies for the robotic exploration of high-temperature environments, such as the Venus surface, Mercury, or the deep atmosphere of Gas Giants.
Radioisotope Power System Program (RPSP)	Strategically invests in nuclear power technologies to maintain NASA's current space science capabilities and enable future space exploration missions.

Funding Opportunities in SMD

EARTH SCIENCE DIVISION	
Advanced Component Technologies (ACT)	Develops a broad array of components and subsystems for instruments and observing systems.
Instrument Incubator Program (IIP)	Funds innovative technologies leading directly to new Earth observing instruments, sensors, and systems.
Advanced Information Systems Technology (AIST)	Develops tools and techniques to acquire, process, access, visualize, and otherwise communicate Earth science data.
In-Space Validation of Earth Science Technologies (InVEST)	Enables on-orbit technology validation and risk reduction for small instruments and instrument systems that could not otherwise be fully tested on the ground or airborne systems.

Funding Opportunities in SMD

ASTROPHYSICS DIVISION	
Astrophysics Research and Analysis (APRA)	Supports basic research of new technologies (TRL 1-3) and feasibility demonstrations that may enable future science missions. Also supports science investigations through suborbital flights that often involve a significant level of technology development.
Strategic Astrophysics Technology (SAT)	Develops mid-TRL technologies (TRL 3-6). Each focused Astrophysics program manages an SAT element separate from flight projects: Technology Development for Physics of the Cosmos (TPCOS), Technology Development for Cosmic Origins Program (TCOR), and Technology Development for Exo-Planet Missions (TDEM).
Roman Technology Fellowships (RTF)	Provides opportunities for early-career astrophysics technologists to develop the skills necessary to lead astrophysics flight instrumentation development projects, and fosters career development by providing incentives to help achieve long-term positions. Develops innovative technologies that enable or enhance future astrophysics missions.
HELIOPHYSICS DIVISION	
Sounding Rockets and Range Program	Develops new sounding rocket and range technologies; serves as a low-cost testbed for new scientific techniques, scientific instrumentation, and spacecraft technology eventually flown on satellite missions.
Heliophysics Technology and Instrument Development for Science (H-TIDeS)	Supports basic research of new technologies and feasibility demonstrations that may enable future science missions. Also supports science investigations through suborbital flights that often involve a significant level of technology development.

Other STMD Opportunities

- **NIAC Program** - Early stage program for mission concept analysis of high-impact new technologies
  - https://www.nasa.gov/directorates/spacetech/niac/index.html#.VQb6I0jJzyE
- **Small Spacecraft Technology Program** - Builds and flies cubesats for technology demonstration
  - https://www.nasa.gov/directorates/spacetech/small_spacecraft/index.html#.VQb6QkjJzyE
- **Game Changing Development Program** - Bridges the ”TRL valley of Death” (roughly TRL 3 to 6)
  - https://www.nasa.gov/directorates/spacetech/game_changing_development/index.html
- **Space Tech Research Grants** - NASA Space Tech Research Fellowships (students), Early Career Initiative (new profs), Early Stage Innovations (all profs)
  - https://www.nasa.gov/strg#.VQb6T0jJzyE
- **Prizes and Challenges** - Difficult problems require creative solutions, with prize purses!
  - https://www.nasa.gov/solve/index.html
- **Flight Opportunities Program** - Competition selected free balloon flights, sounding rockets, and small orbital payloads
  - https://www.nasa.gov/directorates/spacetech/flightopportunities/index.html
- **iTech Initiatives** - Innovative ideas in partnership with NASA
  - https://www.nasa.gov/directorates/spacetech/itech